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The Application of Microencapsulated Phycocyanin as a Blue Natural Colorant to the Quality of Jelly Candy

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Abstract. Phycocyanin is a blue color pigment which can be extracted from *Spirulina* sp. makes it potential to use as an alternative natural dye in the food product. The aim of this research was to determine the application of microencapsulated phycocyanin processed using spray dried method to the jelly candy. As a natural blue colorant, phycocyanin was expected to be safe for the consumer. The jelly candy was evaluated on the characteristics of its moisture, ash, Aw, pH, color appearance, and phycocyanin spectra with FTIR. The phycocyanin was microencapsulated using maltodextrin and Na-alginate as the coating materials (maltodextrin and Na-alginate in ratio 9:1.0 w/w). The spray drying process was operated with an inlet temperature of 80°C. The various concentrations of microencapsulated phycocyanin were added to the jelly candy such as 0%, 1%, 3%, 5% and jelly candy with brilliant blue used as comparison, each called PC, PS, PT, PL, and PB. The results showed that the various concentrations of phycocyanin added on the jelly product had significantly different on moisture content, Aw, and blue color. The FTIR spectra indicated that phycocyanin still persisted on the jelly candy. PL was the best jelly candy with the bluest color under PB.

Keywords: blue colorant, jelly candy, microencapsulated, natural dye, phycocyanin

1. Introduction

Candy is one of food which favored by various age groups. Jelly candy is made by gelling agent and sweetener which forming a certain texture [1]. Jelly candy usually added food colorant to attract the consumer attention, where 85,7% of candy contain synthetic dyes [2]. One of the synthetic dyes which often added to candy is Brilliant Blue FCF [3]. Brilliant Blue is not resistant to oxidation [4], consuming in the large quantities able to cause carcinogenic. Phycocyanin is one of natural blue colorant that can be used and contained in Spirulina [5].

Phycocyanin is more resistant to oxidation because of its function as antioxidant, anti-cancer, anti-inflammatory, and antiviral [6]. The phycocyanin weakness is its blue color is not resistant to pH and temperature [7] which causes the color to fade. Therefore, microencapsulation to phycocyanin is performed to change the form from liquid to powder [8] and preserve the color during storage.

Phycocyanin microcapsule addition to the jelly candy formulation is expected to affect its quality, besides bright blue color also has properties as an antioxidant. The aim of this study was to determine the effect of phycocyanin microcapsule addition to the quality of jelly candy.

2. Methods

2.1. Materials
The ingredients for the making of jelly candy includes sugar, glucose, and seaweed purchased from local market in Semarang. Phycocyanin was extracted from *Spirulina* sp. powder (PT. Neoalga, Sukoharjo, Indonesia) [9] with modification Coating materials: maltodextrin DE 10 (CV. Multi Kimia Raya, Semarang, Indonesia) and Na-alginate (PT. Selalu Lancar Maju Karya, Jakarta, Indonesia). Brilliant blue FCF synthetic dyes (CV. Indrasari, Semarang, Central Java).

2.2. Phycocyanin Microencapsulation
Phycocyanin microencapsulation [10] with modification was performed by homogenization using homogenizer (Ultraturrax T50 Basic Ika Werke, Germany) on phycocyanin extract with coating materials maltodextrin : Na-alginate with ratio 9%: 1% (w/v) toward the phycocyanin extract at speed 4500 rpm for 2 minutes. The homogeneous sample then processed into microencapsulation by the spray dryer (PlantLab, England) with an inlet temperature of 90°C. The microcapsule obtained then stored at dark glass bottle coated with aluminum foil.

2.3. The Making of Jelly candy
First, weighing seaweeds and sugar each for 200 grams. Seaweeds then blended with 500 ml of warm water (±40°C) until fine, while sugar dissolved into 600 ml of water. The fine seaweed was poured into sugar solution and stirred until homogeneous. The phycocyanin microcapsule which had been diluted with 100 ml of water was added in a different concentration of 0%(PC), 1% (PS), 3% (PT), and 5% (PL). After being well-mixed then formed using a pan. As the comparison, synthetic dyes Brilliant Blue FCF 1% (PB) was used.

2.4. Ash Content
The ash content was measured according to SNI 01-2891-1992. Several samples were ashes by the furnace at 550°C until becoming an ash, then cooled for 15-30 minutes at desiccator then weighed. Ash content is a difference between sample before and after ashes divided by initial sample weight multiplied by 100% [11].

2.5. Moisture content
The moisture content was measured according to SNI 01-2891-1992. The sample was heated using an oven at temperature 105°C for 24 hours. Ash content is a difference between sample before and after ashes divided by initial sample weight multiplied by 100% [11].

2.6. Aw and pH
The Aw measured by using Aw meter (rotronic HYGROPALM), while pH measured by using pH meter (pH meter TPX-90i Chemical Laboratories Co., Ltd.)

2.7. Color
The color was measured by Chroma-meter (CR-200 Minolta) where L (Lightness) indicated brightness, a indicated green-red color, and b indicated blue-yellow color [12].

2.8. Fourier Transform Infrared Spectroscopy (FTIR)
The molecule structure of phycocyanin on jelly candy was measured by FTIR using spectra IR 4000-400 cm^{-1} at room temperature [13].

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2.9. Statistical Analysis
This study using Completely Randomized Design with 1 factor, phycocyanin microcapsule concentration. The data obtained from triplication of an assay and analyzed using SPSS 17. The advanced test was performed using Tukey analysis.

3. Results and Discussion

Table 1. Ash content, moisture content, Aw, and pH of jelly candy

No	Phycocyanin concentration	Ash Content (%)	Moisture content (%)	Aw	pH
1	PC	$1{,}757 \pm 0{,}015^{c}$	$54{,}527 \pm 0{,}374^{a}$	$0{,}863 \pm 0{,}002^{a}$	$6{,}400 \pm 0{,}200^{a}$
2	PS	$1{,}290 \pm 0{,}225^{b}$	$54{,}560 \pm 0{,}503^{a}$	$0{,}869 \pm 0{,}005^{ab}$	$6{,}600 \pm 0{,}265^{a}$
3	PT	$0{,}950 \pm 0{,}010^{a}$	$58{,}683 \pm 0{,}270^{b}$	$0{,}875 \pm 0{,}002^{bc}$	$6{,}567 \pm 0{,}208^{a}$
4	PL	$0{,}897 \pm 0{,}109^{a}$	$61{,}693 \pm 0{,}905^{c}$	$0{,}879 \pm 0{,}001^{c}$	$7{,}100 \pm 0{,}100^{b}$
5	PB	$1{,}003 \pm 0{,}055^{ab}$	$62{,}203 \pm 0{,}261^{c}$	$0{,}895 \pm 0{,}004^{d}$	$7{,}467 \pm 0{,}153^{c}$

Note: PC: jelly candy with the addition of 0% phycocyanin microcapsule
PS: jelly candy with the addition of 1% phycocyanin microcapsule
PT: jelly candy with the addition of 3% phycocyanin microcapsule
PL: jelly candy with the addition of 5% phycocyanin microcapsule
PB: jelly candy with the addition of 1% brilliant blue
The data was the average of triplication ± standard deviation.
Different superscript on the same column indicates significantly different at level α 0,05

3.1. Ash Content
The jelly candy with the addition of phycocyanin reduces the ash content. This caused by the increasing of phycocyanin concentration, as well increasing the moisture content on jelly candy so the ash content decreased. Meanwhile, compared to jelly candy with the addition of 1% brilliant blue was not significantly different to jelly candy with phycocyanin microcapsule. The ash content ranged between 0,897%-1,757%. This result was higher compared to Buntaran *et. al.*, [11] which adding tomatoes extract on candy and produced ash content around 0,6-0,8.

3.2. moisture content
jelly candy is an intermediate moisture food, rich in sugar and other compounds which are hygroscopic and hard to dry [14]. Moisture content plays an important role to determine the quality of jelly candy, especially to form the texture. Based on the table above, the higher of phycocyanin microcapsule would increase the moisture content on jelly candy. If compared to jelly candy with the addition of brilliant blue, jelly candy with 5% of phycocyanin microcapsule was significantly different on its moisture content. The moisture content of jelly candy in this study ranged between 54,527%-61,693%. The higher level of moisture on jelly candy due to water was not able to evaporate perfectly as the temperature applied was not too high and phycocyanin will be damaged at high temperature [6]. On the other hand, the existence of sugar compound will cause the color to change if heated at high temperature. This result was higher compared to Delgado and Banon [14] which producing the jelly candy with the moisture content around 21%. Whereas Muzzaffar *et. al.*, [16] add pumpkin to candy resulting in the moisture content around 20,1%. According to SNI 3547.2-2008 about soft cotton candy, the maximum moisture level is 20%.

3.3. Aw
Activity water is an important factor related to food decay and affects toward shelf-life, while fungi start to grow at Aw 0,7 (Utomo, 2014). The Aw value associated with the moisture content. The

addition of phycocyanin microcapsule on jelly candy affects the Aw value. The Aw value increased along with the increasing of phycocyanin microcapsule, ranged around 0,863-0,879. This result was higher compared to Charoen *et. al.*, [18] where *Psidium guajava Linn.* leaves extract was added into jelly candy so produced Aw value around 0,75-0,79.

3.4. pH
The pH of jelly candy with phycocyanin microcapsule addition increased along with the increasing of phycocyanin microcapsule percentage. However, pH produced was neutral between 6-7. The pH value of this study was higher or around neutral because it aimed to maintain the phycocyanin as a natural colorant. The phycocyanin was stable at pH 5,5-6 and able to preserve effectively at pH 7 [7].

Table 2. Jelly candy Color

No	Phycocyanin concentration	L	a	B
1	PC	$42,943 \pm 0,919^{c}$	$0,033 \pm 0,194^{b}$	$0,923 \pm 0,471^{a}$
2	PS	$38,550 \pm 0,654^{b}$	$-0,290 \pm 0,087^{ab}$	$-1,303 \pm 0,202^{b}$
3	PT	$40,743 \pm 1,253^{bc}$	$0,623 \pm 0,080^{c}$	$-4,707 \pm 0,499^{c}$
4	PL	$41,200 \pm 0,850^{bc}$	$1,063 \pm 0,275^{c}$	$-7,297 \pm 0,869^{d}$
5	PB	$31,050 \pm 2,453^{a}$	$-0,423 \pm 0,100^{a}$	$-9,660 \pm 0,867^{e}$

Note: PC: jelly candy with the addition of 0% phycocyanin microcapsule
PS: jelly candy with the addition of 1% phycocyanin microcapsule
PT: jelly candy with the addition of 3% phycocyanin microcapsule
PL: jelly candy with the addition of 5% phycocyanin microcapsule
PB: jelly candy with the addition of 1% brilliant blue
The data was the average of triplication ± standard deviation.
Different superscript on the same column indicates significantly different at level α 0,05

3.5. Color
Based on Table 2, the higher of phycocyanin microcapsule percentage added to jelly candy, the color was getting blue, it showed by the increasing level of Lightness (L) and blue (-b). This indicated that phycocyanin able to persist during jelly candy processing. However, at the addition of phycocyanin microcapsule 5%, the intensity of blue color was under jelly candy with 1% of brilliant blue FCF addition. The different result showed by Charoen *et. al.*, [18] where the addition of *Psidium guajava* leaves extract on jelly candy declining the value of L and b.

3.6. Fourier Transform Infrared Spectroscopy (FTIR)
jelly candy observed its phycocyanin spectra by FTIR. The result can be seen in Figure 1. The constituent component of jelly candy by FTIR spectrophotometrically measured at 400-4000 cm^{-1}. According to FTIR spectra, it can be seen that the five samples of jelly candy had the similar wavelength, it means that the constituent compound of jelly candy was same, seaweed and sugar (sucrose). Seaweeds constituent compound visible at 845-930 cm^{-1} of wavelength [19]. Whereas, the result of this study was around 848,68-910,40 cm^{-1}, while at 848,68 cm^{-1} wavelengths was the peak for Esther sulfate which was a functional group of carrageenan. While the peak for sucrose was detected at 995,27 cm^{-1} wavelengths. This result was similar with Adina *et. al.*, [21] where sucrose was detected at 995 cm^{-1} wavelengths. Phycocyanin was detected at 1651,07 cm^{-1} wavelengths and not contained on PC and PB. This result was similar with Gang *et.al.*, [22], that the C-Phycocyanin's absorption peaks was 1650 cm^{-1}. But the different result showed by Suzery *et. al.*, [23] that phycocyanin spectra appeared at 1550-1600 cm^{-1} wavelength.

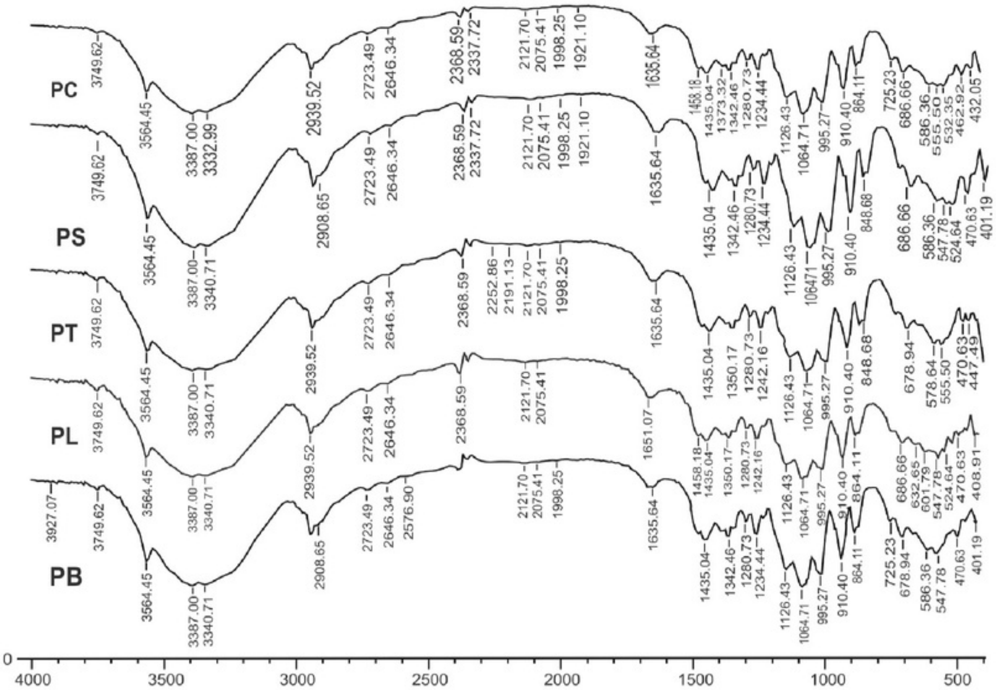

Figure 1. FTIR jelly candy

Note: PC: jelly candy with the addition of 0% phycocyanin microcapsule
PS: jelly candy with the addition of 1% phycocyanin microcapsule
PT: jelly candy with the addition of 3% phycocyanin microcapsule
PL: jelly candy with the addition of 5% phycocyanin microcapsule
PB: jelly candy with the addition of 1% brilliant blue

4. Conclusion

The application of phycocyanin microcapsule on jelly candy has not yet produced the moisture content which complies with Indonesian National Standard. However, the addition of 5% phycocyanin microcapsule able to produce bright blue color under brilliant blue dyes. This showed by measurement using chroma-meter and FTIR, that phycocyanin still persists during the processing of jelly candy.

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